THE FIXATION OF ATMOSPHERIC NITROGEN AS CYANAMIDE.

IN NATURE of August 30, 1906, an article was published describing the Birkeland Eyde process for the fixation of atmospheric nitrogen by electrothermic methods and the conversion of the nitric acid so obtained into calcium nitrate, which is used as a fertiliser in place of Chili saltpetre. Since that date the Birkeland-Eyde works at Notodden, in Norway, have been considerably enlarged, owing to the success which met their initial efforts. The necessity of obtaining large quantities of nitrogen in a form suitable for fertilising purposes does not require to be reiterated again, because the fact that the available sources are being depleted, and the demand for nitrogen for agricultural purposes continually increases, is now universally recognised. This has led many investigators to endeavour to fix atmospheric nitrogen in some other form, which it is hoped will be more economical than that of direct oxidation in the electric arc.

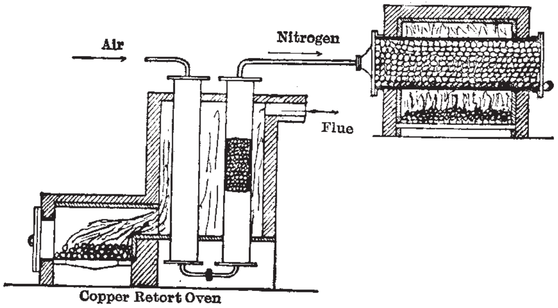


FIG. 1.—Nitrogen Absorption Retort.

The amount of Chili saltpetre exported in 1907 was 1,740,000 tons, and in order to replace this by the fixation of atmospheric nitrogen, it is necessary to employ 280,000 tons of the gas, and this is the amount which, it is calculated, is contained in the atmosphere over every nine acres of the globe. Another method of fixing nitrogen is known, and that is the formation of calcium cyanamide by the heating of calcium carbide in a stream of nitrogen obtained from the atmosphere. The researches which led to the discovery of calcium cyanamide were originally commenced by Drs. Frank and Caro in 1895, when they were endeavouring to produce cyanides by heating a mixture of calcium carbide and sodium carbonate in presence of nitrogen. The results were not very satisfactory, and therefore barium carbide was substituted, and this substance was found to absorb nitrogen with great avidity at between 700° and 800° C. It was intended to treat the barium cyanide with potassium or sodium carbonate, and thus produce the cyanides. On examination of the products produced, however, it was found that not only did barium carbide produce barium cyanide, but also a more complex compound was formed, which upon examination proved to be barium cyanamide according to the equation :—

$$BaC_2 + 2N = BaCN_2 + C.$$

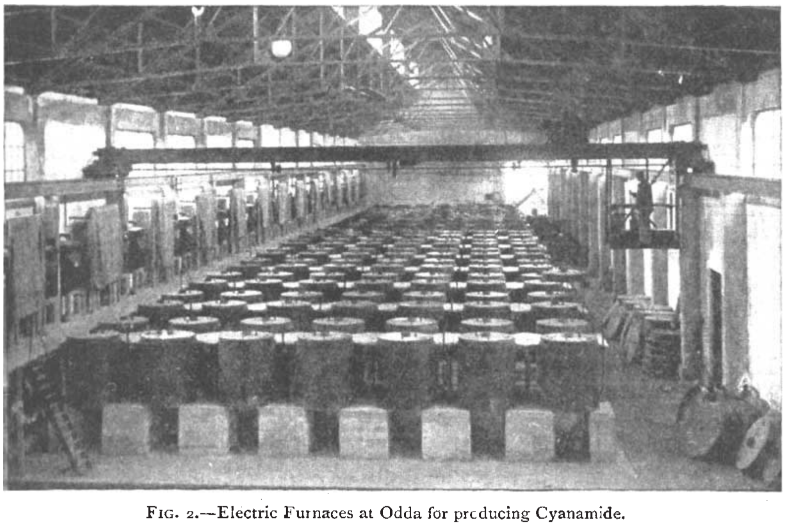


FIG. 2.—Electric Furnaces at Odda for producing Cyanamide.

The product obtained in the reaction usually contained 30 per cent. of barium cyanide and 40 per cent. of cyanamide, the remainder consisting of barium oxide and carbon. It was found, however, that the barium cyanamide and barium cyanide could easily be converted into potassium cyanide by melting with potassium carbonate as follows :—

$$Ba(CN)_2 + BaCN_2 + C + 2K_2CO_3 = 4KCN + 2BaCO_3.$$

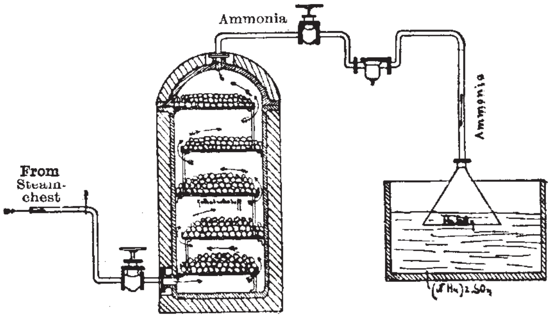


FIG. 3.—Ammonia Producing Apparatus.

Experiments were then taken up with calcium carbide, and investigation showed that by altering the conditions it was possible to convert the whole of the calcium carbide into cyanamide according to equation 1. Now when calcium cyanamide is decomposed by means of water, ammonia is produced thus :—

$$CaCN_2 + 3H_2O = CaCO_3 + 2(NH_3).$$

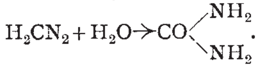
It seemed, then, that it might be possible to obtain the ammonia for purposes of fertilisation, that is to say, employ cyanamide directly as a manure, but as the reaction only takes place with water at high temperatures, agricultural authorities were inclined at first to doubt the possibility of employing this product, as it was presumed the ammonia would probably not be liberated by the moisture of the soil. However, experiments showed that the cyanamide actually does decompose in the soil, and that it acts as a source from which plants can obtain the nitrogen which they require for nutriment. The product has therefore been put upon the market under the name of "Nitrolim." Some difficulties, however, were met with, one being that the finished product often contains some quantities of calcium oxide, therefore on exposure to moist atmosphere the nitrolim increased in bulk, which was objectionable for storage purposes, as the jute sacks in which it was contained burst. By, however, taking precautions to line the sacks first of all with double paper, this difficulty was got over, and also by improved methods of manufacture the amount of lime produced was lessened.

As regards the actual part played by cyanamide in the soil various theories have been put forth; *e.g.* it would appear that when brought into contact with the ground the cyanamide is first decomposed through the action of the moisture and also of the carbon dioxide in the soil as follows :—

FIG. 4.—Isere Valley, Nôtre Dame de Briançon.

$$CaCN_2 + H_2O + CO_2 \rightarrow H_2CN_2 + CaCO_3,$$

and the free cyanamide will then, by absorption of water, probably be further decomposed into urea,



$$H_2CN_2 + H_2O \rightarrow CO\begin{matrix} \diagup NH_2 \\ \diagdown NH_2 \end{matrix}.$$

Also the decomposition is greatly assisted by the myriads of microbes which are invariably found in cultivated soil.

Experiments have shown that calcium cyanamide is more suitable in some soils than in others, *e.g.* if the soil is in an acid state it is necessary previously to lime it. Such soils are found in high moorland and in sandy places because they are very poor in lime, and when applied to such land, cyanamide, unless lime is first added, is distinctly harmful, but with most other soils it is very satisfactory.

Nitrolim can also be mixed with other fertilisers, such as basic slag, potassium salts or superphosphate, but with this latter particular precautions have to be employed owing to the free phosphoric acid combining with the free lime in the cyanamide. This difficulty, it is stated, has now been got over. One advantage which cyanamide has over Chili saltpetre is that it is less soluble in water, and is therefore not so liable to be washed away in the drains and so lost, consequently the unchanged cyanamide which may have been left in the ground after the first harvest is readily available for the succeeding one.

Cyanamide is manufactured from calcium carbide of the same quality as that which is used for illuminating purposes. The carbide as it comes from the electric furnace is ground up and charged into retorts, which are made of fire-proof material, and are mounted in a furnace similar to the retorts employed for the manufacture of gas. (Fig. 1 shows this arrangement diagrammatically.) The nitrogen is then passed over the carbide, the retort being maintained at a temperature of from 800° to 1000° C. The nitrogen is produced either by the Linde system of fractional distillation of the air or by passing air over heated copper turnings, the resulting copper oxide being reconverted to the metal by passing reducing gases over it. In the Linde process the oxygen which remains after the separation of the nitrogen is a useful bye-product. As soon as the carbide in the retorts is saturated with nitrogen—a fact which becomes evident by the controlling gas meter coming to a standstill—the calcium cyanamide is extracted in the form of a hard cake, and is cooled in vessels from which air is excluded. When cool it is ground into a fine powder and is ready for use.

During the last year a new electric furnace has been devised for heating the carbide while it is absorbing the nitrogen, and this has given such satisfaction that now all the older retorts are being replaced by the electrically heated ones. The process is cheaper, and the operating costs per furnace are lower, also the life of the retort is practically unlimited, which was not the case with the older retorts (Fig. 2 shows a number of these retorts in position.)

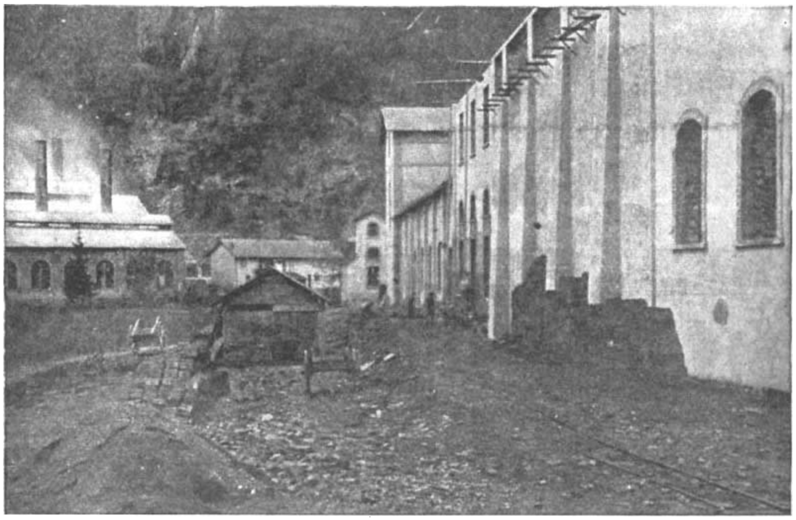


FIG. 5.—Main Buildings at Nôtre Dame de Briançon.

The yield of carbide at most works is about two tons per kilowatt year, and two tons of carbide will absorb practically 500 kilograms of nitrogen in the form of nitrolim. A power of about 2⅔ h.p. is required per year for fixing each ton of nitrogen, and in addition to this about one-third horse-power is required for the grinding and all other mechanical operations. Consequently, to produce sufficient nitrolim to take the place of all the Chili saltpetre at present consumed annually, plant developing no less than 800,000 h.p. would be required. Not only is nitrolim useful as a fertiliser, but quite a large variety of chemical products have been made by means of it. For instance, by melting it with a flux, a mixture containing 25 per cent. of potassium cyanide, which is found to work quite as efficiently for the extraction of gold and silver as the pure product, is produced. It comes on the market under the name of "Surrogate." Ammonia may be produced very readily from this product, and may be collected pure or used for making salts of ammonia. (Fig. 3 shows diagrammatically the form of plant employed.) Another product is dicyandiamide, which is being used in increasing quantities for the manufacture of organic dyes. Besides which there are urea, thiourea, ferricyanide, and a variety of other products.

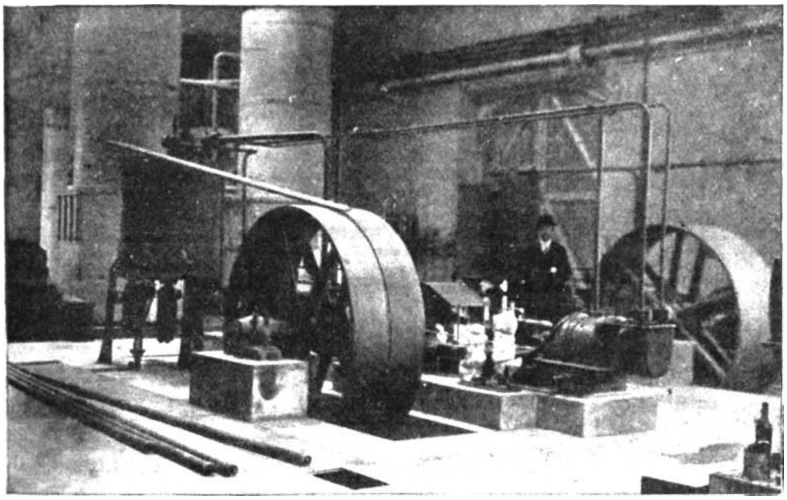


FIG. 6.—Linde Machinery.

As a commentary upon the Birkeland-Eyde process worked at Notodden, it is of interest to notice that the Cyanamide Company at Odda fix about the same quantity of nitrogen as the Birkeland-Eyde; but whereas the former employed about 25,000 kilowatts of power, the energy required by the latter company is between five and six thousand kilowatts. It would thus appear that the actual fixation is cheaper in the form of cyanamide than in that of calcium nitrate. At the end of the present year it is hoped that works having a total output of 45,000 tons of nitrogen will be in operation, and in the course of next year a correspondingly large increase in production of this product is predicted. It should be mentioned that the first plant upon an industrial scale was started about two and a half years ago, at Piano d'Orta, in Central Italy, with a yearly production of about 4000 tons of nitrolim. These works are now being increased to a capacity of 10,000 tons. Other important works are being started in Italy; the power employed is hydro-electric.

Works are being erected in Austria-Hungary, and at the present time a water-power installation, giving at least 50,000 h.p., is being erected at Almissa. In France the Société Française des Produits Azotés has installed works at Nôtre Dame de Briançon (Haute Savoie) having an output of 4000 tons, and these have been in operation for about six months. In Germany, at Westeregeln and Brühl, on the Rhine, 10,000 tons of nitrolim are being annually manufactured. It should be noticed, however, that the works at Brühl do not employ water power, but as the coal in this district is cheap, it is used in place of water power. In the United States the American Cyanamide Company are constructing works on the Canadian side of the Niagara Falls, with a capacity of from five to six thousand tons per annum, which it is hoped to enlarge later on so as to produce 40,000 tons.

The chief British enterprise is the North-Western Cyanamide Company, Ltd., which has erected works at Odda. Figs. 4 and 5 show the Isere Valley, Nôtre Dame de Briançon, and the main buildings of the cyanamide works. Fig. 6 shows the Linde machinery employed there for fractional distillation of the air.

F. M. P.

THE EDUCATION OF THE BLIND.[1]

THE jubilee year of the Institution for the Blind at Illzach-Mülhausen has been celebrated by the publication of a "Festschrift," which contains addresses and papers by Prof. Kunz and others at the congresses regarding the blind held in Frankfort in 1882, Amsterdam, 1885, Kiel, 1891, Berlin, 1898, Paris, 1900, Breslau, 1901, Halle, 1904, Leipzig, 1905, and in Rome, 1906. There is first an interesting account of the development of the Institution at Illzach since its foundation in 1856. Institutions for the blind were founded in various cities long before this date. Thus, to select from a long list of the chief cities of the world, we find one in Paris in 1784, in Liverpool (the first English institution), 1791, Edinburgh, 1793, London, 1799, Berlin, 1806, St. Petersburg, 1807, Stockholm, 1808, Dublin, 1810, Barcelona, 1820, Munich, 1826, New York, 1831, Bern, 1836, Padua, 1838, and Madrid, 1842.

The home at Illzach was at first small and modest, but it grew rapidly, and now it is one of the best equipped blind asylums. From the first its founders had in view that it was not merely to be a home for the blind, but a school in which all the elements of an ordinary education, and also of a technical education, could be taught. Nothing is more ingenious than the methods now adopted for the education of the blind, more especially by the sense of touch. Reading by raised type, or by a system of raised points so grouped as to represent numerals or letters, arithmetic, grammar, geometry, geography by raised maps, natural history by specimens of plants and animals or by anatomical models, or the outlines of plant and animal forms in bas-relief, music—theoretical, vocal, and instrumental—and gymnastics, and many technical arts are also taught, such as sewing,

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[1] Geschichte der Blindenanstalt zu Illzach-Mülhausen i E. Während der ersten fünfzig Jahre ihrer Tätigkeit, ferner deutsche, französische, und italienische Kongressvorträge und Abhandlungen über das Blindenwesen, Prof. M. Kunz, Direktor der Anstalt, 1856–1906. Pp. 346. (Leipzig: Wilhelm Engelmann, 1907.)